U.S. Department of Agriculture Agricultural Research Service Vol. 36, No. 9, October 1988

Agricultural Research

ARS Developed New Crops and Products

Burdensome surpluses of agricultural commodities and byproducts have been with us for the better part of 50 years, and they have been the subject of various government programs. To produce less, farmers were enticed into subscribing to Federal set-aside and payment-in-kind programs.

Those were fairly successful programs and when the United States was a dominant exporter of agricultural goods, helped keep many surpluses in check. But with the present expansion of agricultural production capabilities in other countries, competition for export markets has heightened and surpluses are mounting.

One approach to the problem of excess production has been to develop new markets for agricultural products through research. The Agricultural Research Service has been very successful in creating such markets with new products made from corn, soybeans, and cotton or from animal and dairy products.

Many of the new products could compete successfully with imported petroleum products, on which we are greatly dependent. Examples are surfactants, plasticizers, plastics, paints and other coatings, and lubricants. In some situations, new products have already replaced imported agricultural products, such as xanthan gum made by fermentation from corn that substitutes well for imported plant gums as a thickening agent in foods.

Sometimes a research program leads to a product that has such new properties or capabilities that it creates a totally new market. An excellent example is super slurper, which is made from cornstarch; it is the strongest moisture-absorbing material ever encountered. It did not replace any existing material, and uses had to be developed for it. Today it is used in highly-liquid-absorbing diapers, improved batteries, seed coatings for improved germination of pine seeds for tree production, and in many other diverse ways.

Surplus corn has found a good market in biodegradable plastic. Use of this product in the form of garbage and shopping bags, food containers and utensils, and agricultural mulching film reduces our dependence on petroleum for our plastics manufacturing, develops a new market for corn, and helps to clean up our environment.

Some products developed by ARS have led to a better and healthier life. Slow-release pesticides encapsulated in cornstarch materials reduce the total amount of active ingredients needed as well as exposure of people, farm animals, and birds to the chemicals.

Another approach to reducing surplus crops is the development of alternative crops that can provide new opportunities for the farmer and for domestic business. Such crops must provide a product that is highly desirable in nonfood and nonfeed markets. That means that the crop or its products should not compete with other American crops but instead create materials that now must be imported.

A papermaking crop such as kenaf, featured on page 6 of this issue, is an excellent example. Farmers can replace corn, beans, cotton, or rice with kenaf, which in turn creates new opportunities for manufacturing paper that now needs to be imported to the annual tune of $4 billion.

Other new crops that ARS is developing include mainly oilseed crops. Several of these crops are essentially ready for commercial production; others are in various stages of development.

- Crambe and meadowfoam can replace imported long-chain fatty acids that are used in lubricants and plastics;
- Jojoba makes an excellent replacement oil for embargoed sperm whale oil for cosmetics and lubricants;
- Lesquerella may replace imported castor oil for lubricants, coatings, and plastics;
- Cuphea oil can be used for fine soaps and shampoos in lieu of imported coconut oil.

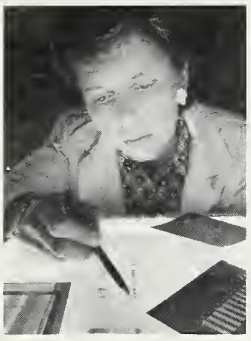
Guayule is being developed by ARS as a domestic crop source of natural rubber, in cooperation with the Department of Defense. Natural rubber and several other imported agricultural products are classified as critical or strategic materials; without their import, the United States cannot continue to produce important consumer goods or industrial products and might not be able to defend itself in time of war. Also, climatic or political changes overseas affect the availability of these materials from time to time and make for undependable supplies at greatly varying prices.

ARS continues to support a varied program with many approaches to solve the problem of farm surpluses. Several of these are going to be paying off soon in terms of new crops or new product opportunities for the farmer and manufacturers.

L.H. Princen
Director
Northern Regional Research Center
Peoria, Illinois

Agricultural Research

Cover: A stand of kenaf, a fibrous plant with potential to supplement wood-based paper pulp, is inspected by ARS soil scientist L.N. Namken at cooperating Rio Farms in Texas' Rio Grande Valley. Photo by David Nance. (88BW1573-16)



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KEITH WELLER

Biologist Donna King examines a "signature" X-ray image of DNA generated by embryos carrying a foreign gene. (88BW1640-19)

Gene Transfers Quick Answers

Animal researchers in ARS have taken another step toward genetically engineered cattle that can resist disease, produce leaner meat or higher quality milk, or have other valuable traits.

"We have developed a biotechnology system that tells us if a gene injected into a fertilized egg is still present in the developing embryo before we implant the embryo into a surrogate animal mother," says molecular biologist Donna A. King at ARS' Beltsville, Maryland, research location.

"We take 25 or so cells from a cow or mouse embryo and mix them with an enzyme, polymerase, that acts as a 'copier machine.' If the gene we are looking for is there, the polymerase will make a million or more copies," King says.

"In this way we can make enough copies for existing tests to detect the new gene," she says. "Until now, researchers have had to wait until an animal was born to see if it still carried the gene inserted into it when it was an egg."

When working with mice—and their 21-day gestation period—scientists can afford to wait until offspring are born to see if an injected gene is still present. "But," she adds, "cattle, with their 280- to 285-day gestation period and costly feed bills, are another story."

By avoiding this delay, the new system could cut the cost of developing reliable gene engineering technology for farm animals, says King's colleague, animal physiologist Robert J. Wall.

"The problem," Wall says, "is that even though DNA—the stuff genes are made of—is placed in an egg, normal laboratory tests can't detect it in the embryo because there is so little of it."

The new system, besides taking some of the hit or miss out of genetic engineering, could bring a tenfold increase in efficiency—30 cows could be used for the same tests that would have formerly required 300. "Perhaps more important," Wall says, "this system saves valuable time while assuring scientists that their gene engineering tests are on track."—By **Vince Mazzola,** ARS.

Donna A. King and Robert J. Wall are at the USDA-ARS Reproduction Laboratory, Beltsville Agricultural Research Center-East, Beltsville, MD 20705 (301) 344-1500. ♦

Diet Needn't Be Spartan

Does having a healthy heart mean you have to give up juicy steaks, mellow cheeses, or fresh eggs?

Not necessarily, says Agricultural Research Service research chemist Rita M. Dougherty. Results of a 15-week study at ARS' Western Human Nutrition Research Center in San Francisco provide new evidence that you can enjoy these foods and—at the same time—drastically reduce the amount of fat in your diet, as well as lower blood pressure and cholesterol. For the study, menus were developed that included red meat and dairy products, yet contained only 25 percent fat.

That's in contrast to the typical American diet, which contains 42 to 44 percent fat. Twelve men stayed on the 25 percent fat menus for 6 weeks. During that time, they were able to lower their blood pressure an average of 10 percent, their cholesterol level, 20 percent.

Those decreases are in line with findings reported from other studies of volunteers or patients who switch from high-fat meals to low-fat menus, Dougherty says, but often those low-fat regimens are "spartan ones that people have trouble staying with for very long."

To make the low-fat meals appealing and satisfying, Dougherty chose tasty substitutes for popular foods typically loaded with fat.

"On the low-fat regimen, we served the same amount of red meat as on the higher fat diet, but it was lean meat—with most of the fat trimmed off," says Dougherty. "We offered milk, but it was skim milk, not whole milk. We chose cheeses such as a low-fat mozzarella in place of a higher fat cheese like cheddar. And we used margarine in place of butter," she explained.

"These are the kinds of substitutions you can easily make at home or when you go grocery shopping. We used foods you can buy at any supermarket."

The study is the tenth in a series that the San Francisco researchers have conducted to provide new clues about the relation of foods to blood pressure and blood cholesterol. The experiment was the first in the series to feature the American Heart Association recommendation that the day's fat intake be spread equally among three types of fat—saturated (such as in cheese and meats); monounsaturated (such as the kind that's in olive oil); and polyunsaturated (found in vegetable oils). It was also the first time the San Francisco researchers chose volunteers who had higher-than-normal blood pressure.—By **Marcia Wood,** ARS.

Rita M. Dougherty is with USDA-ARS Biochemistry Research, Western Human Nutrition Research

Center, P.O. Box 29997, Presidio of San Francisco, CA (415) 556-0132. ♦

Tomatoes May Stay Fresh Longer

If a natural sugar in tomatoes controls ripening and tissue softening, says the Agricultural Research Service's Ken C. Gross, "regulating it could help prevent spoilage that amounts to $5 billion a year."

Gross uncovered the role of galactose, a sugar in plant cell walls, during research in which he injected it into green tomatoes.

He says galactose may initiate a chain reaction in tomatoes that ends by turning on the ripening hormone. But, he adds, the softening that accompanies ripening also makes the fruit more susceptible to mechanical injury and microbial decay.

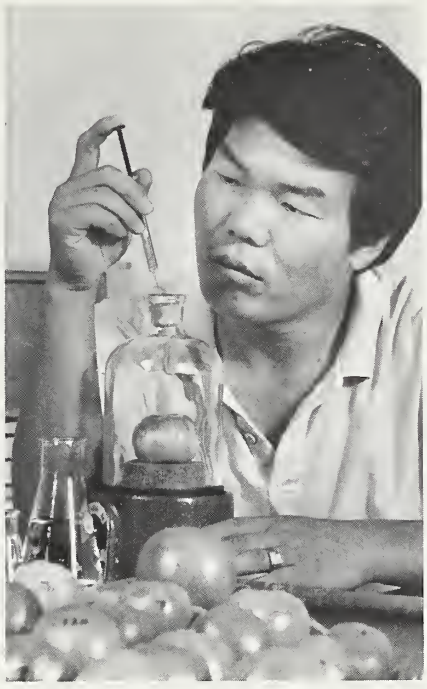
"Galactose stimulates the production of ethylene, a gaseous hormone in tomatoes. Ethylene then turns on synthesis of an enzyme that breaks down cell walls and softens tissues," says Gross, a plant physiologist at Beltsville, Maryland.

"Ripening is genetically programmed in plants. It includes changes in fruit cell walls, which provide structural support and firmness," he says.

Gross will seek to genetically engineer the sugar to slow its role in the ripening process without hurting quality and flavor. "That could cut losses during harvesting, shipping, and marketing and losses to consumers when fruit and vegetables rot too quickly at home on the shelf or in the refrigerator."

He has studied the fruit-ripening process for 7 years, focusing on galactose the last 3 years.

"We're now also studying other types of produce to see if galactose or other sugars play the same role there as it does in tomatoes," he says. "It is probable because all fruit and vegetable cell walls contain galactose and chains of similar sugars that support cell tissues."—By **Karen Mehall,** formerly ARS.



KEITH WELLER

Biological aide Jong-Kee Kim subjects a green tomato to galactose, a plant sugar, which stimulates ripening. (88BW1642-37)

Ken C. Gross is in the USDA-ARS Horticultural Crops Quality Laboratory, Beltsville Agricultural Research Center West, Beltsville, MD 20705 (301) 344-3128. ♦

Don't Overdo the Vitamin A

A word of caution to people over 60: Prolonged daily use of vitamin supplements containing the pure vitamin A could lead to low-level toxicity, report scientists at the Agricultural Research Service Human Nutrition Research Center on Aging at Tufts University, Boston.

The findings came out of an ARS-funded survey of 562 healthy Boston area residents over 60. Fifty percent of those surveyed reported taking vitamin supplements, mostly as multivitamin, multimineral preparations.

According to biochemist Stephen Krasinski, who analyzed the data for vitamin A, "those who had used supplements the longest had the highest blood levels of retinyl esters"—the pure form of A used in vitamin pills.

Although the esters are not toxic themselves, once in the blood they can be converted into free retinol, which is toxic, says Krasinski, who is now with the New England Medical Center.

Chronic toxicity can cause liver damage, bone and joint pain, and scaly dermatitis. And acute toxicity, due to large overdoses, can cause headaches.

The highest blood levels of retinyl esters in this study—two to three times normal—"were nowhere near the levels we see in people with reported cases of acute vitamin A toxicity," he says. "But four of the five survey participants who had the highest levels had early signs of liver damage." Those five participants had taken supplements daily for more than 5 years. Dosage ranged from as little as the Recommended Dietary Allowance for vitamin A (5,000 i.u.) to four times the RDA.

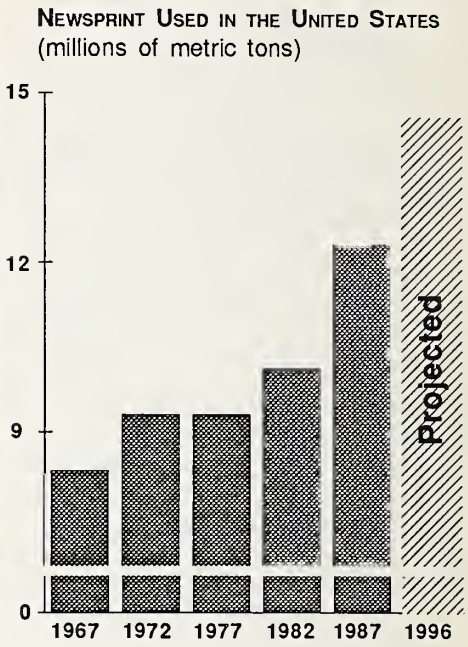
"This suggests that the elderly should not use supplements to meet their requirement; rather, they should eat fruits and vegetables rich in beta carotene," he says.

He found no evidence that fruits and vegetables increase blood levels of retinyl esters. In plant sources, vitamin A is mainly packaged as beta carotene, which is virtually nontoxic. In animal sources, it is usually found as retinyl esters concentrated in the liver.

A spokesman for the Vitamin and Mineral Supplement Manufacturers Association says that most supplemental vitamin A is sold as part of multiple vitamins. However, Krasinski noted that there are multivitamin preparations that don't contain A and many beta carotene supplements on the market.—By **Judy McBride,** ARS.

Stephen Krasinski is at the USDA-ARS Human Nutrition Research Center on Aging, 711 Washington St., Boston, MA 02111 (617) 956-5864. ♦

Kenaf Paper:
A Forest-Saving Alternative



About 2 percent of the wood-based newsprint used in the United States could be replaced by kenaf paper when a new kenaf processing plant planned for Willacy County, Texas, becomes fully operational.

It is the land of cotton and dreams, where generations of farmers have turned to make a living and where generations more are yet to come.

But while cotton generally fares well in Willacy County, Texas, farming is down, oil and gas prices are down, and unemployment, at more than 15 percent, continues to climb. Some in this southern Texas county are placing their hope for better days on a fibrous crop closely related to cotton, a crop some say will not only help Willacy County with its problems but will help meet the nation's growing need for newsprint paper.

The crop is called kenaf, and its future looks as bright as cotton's was 200 years ago.

"We obviously believe it is a very good crop with an excellent future," says Charles S. Taylor, general manager of Kenaf International, a joint-venture partnership based in Bakersfield, California.

"Kenaf is a fiber that is yearly renewable. It can be grown throughout the South, where some papermills already exist to process native hardwood trees. It provides an alternative crop for farmers. It also provides an opportunity to build new mills for paper made from kenaf," he says.

Together with Canadian Pacific Forest Products, the second largest paper manufacturer in North America,

"We obviously believe [kenaf] is a very good crop with an excellent future."

Charles S. Taylor, general manager of Kenaf International, Bakersfield, California.

Taylor's group expects to break ground later this year in Willacy County for a papermill that will be the first of its kind in the United States. It will take harvested kenaf fiber from the Rio Grande Valley and turn it into massive rolls of newsprint.

Estimated cost of the project, including power plant: $400 million.

"We figure, when it's all up and going, the mill will provide 300 to 400 jobs in the area," Taylor says. "And that's not counting the construction workers who will build it or the farmers who'll be growing kenaf for us."

The plant will be built on 40 acres of land near Raymondville, the seat of Willacy County. Construction and startup are expected to take up to 36 months. Once full capacity is realized, the operation will be able to handle production of 40,000 acres of kenaf each year, processing it into 225,000 metric tons of newsprint.

Kenaf International is the leader in kenaf commercialization, a relatively slow process that has picked up steam in the last 18 months. Relying on 20 years of research by USDA's Agricultural Research Service, the group hopes to make kenaf a common word among newspaper publishers across America.

There are several factors that make kenaf attractive to private industry. First, it is a fast-growing, highly productive crop. An acre of kenaf reaches a height of 15 to 18 feet in 4

months and yields 7 to 10 tons of dry-weight fiber.

Second, kenaf produces a paper product that is as tough as wood-pulp paper but is generally brighter and more appealing to the eye and doesn't yellow quickly.

"There is also less ink rub-off with kenaf paper," says Dan Kugler, an agriculture economist and manager of USDA's Kenaf Demonstration Program. "The consumer will like that because you can read your newspaper instead of wear it."

Kenaf can tolerate salty water to a certain extent and may be successfully grown without an extensive investment in irrigation equipment. It is easy to store and requires less energy to process than wood pulp.

Kenaf Fiber Could Cut Newsprint Imports

Last year, U.S. newspaper publishers used 12 million metric tons of newsprint. Two-thirds of it was imported at a cost of nearly $4 billion. By 1996, industry analysts expect the demand to reach 14.5 million tons a year.

Aside from newsprint, Kugler says the bamboolike kenaf can be used for several other fiber products. It can be made into carpet backing and padding, roofing felt, cattle feed, chicken litter, fine and coated papers, fire logs, and cardboard.

In Africa, where the plant originated, and in parts of Asia, it is often made into clothing, nautical rope, twine, and cigarette paper. Some experts believe that with refinements, kenaf could be made into paper for printing U.S. stamps and currency.

"Without a doubt, kenaf has already proven its wide-ranging potential," says Kugler, who works out of USDA's Cooperative State Research Service. "The technical feasibility of the fiber is there, it's been proved. Now we just have to keep moving it into commercialization."

Kenaf—An Early Winner

Research on kenaf began in 1956. ARS chemist Fontaine R. Earle led a team of scientists and technicians in search of a supplement to wood pulp in the manufacture of paper. At the Northern Regional Research Center in Peoria, Illinois, some 500 fiber crops were examined, of which 92 were selected for closer study. Kenaf was among them.

Over time, kenaf was singled out as the best candidate for continued study. Work was begun under chemical engineer T.F. Clark at the Center, where researchers explored the pulping characteristics of the crop and the subsequent strength of the paper. Organic chemist Marvin O. Bagby took over the program in 1974 and began newsprint work 2 years later.

According to Bagby, ARS research on kenaf lapsed in 1978. He says work was halted to allow private industry an opportunity to further develop the crop.

The first commercial press run on kenaf newsprint was done at the Peoria Journal-Star in 1977. The outcome was described as successful, prompting at least eight other daily newspapers to begin test runs. The last newspaper to print on kenaf paper was the Bakersfield Californian. Two sections of that daily ran on 12 rolls in July 1987.

Since 1986, part of the developmental effort has been by the Kenaf Demonstration Program, funded by ARS and the Cooperative State Research Service. Through cooperative agreements with several firms—including Kenaf International, Canadian Pacific Forest Products, and Rio Farms, Inc., a kenaf-growing project—the program has helped kenaf make the jump from laboratory to industry.

Now the program has come full circle. ARS money was restored for kenaf research earlier this year, and Bagby believes it will help convince newsprint executives to more readily accept kenaf as a workable supplement to wood-based paper products.

"The paper industry is very conservative," he says. "They don't like to be the first to try something new but they don't want to be too far second. I think our continuing research and the new mill will probably bring them around."

The $300,000 research funds will be shared by two ARS labs: the Conservation and Production Systems Research Laboratory in Weslaco, Texas, and the South Central Agricultural Research Laboratory in Lane, Oklahoma. Areas of study are expected to include nutrient and water requirements of the crop,

DAVID NANCE

Both pulpy center and fibrous exterior of bamboolike kenaf are used to produce newsprint and other fiber products. (88BW1576-10)

DAVID NANCE

Like cotton, its close relative, kenaf leaves show wide genetic variation in shape ranging from slightly to deeply lobed. (88BW1573-23)

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Chemist Marvin Bagby of the Northern Regional Research Center holds a stalk of kenaf and two newspaper issues that are printed on kenaf paper.

variety improvement, nematode and insect resistance, moisture stress, fiber separation, storage requirements, handling procedures and new product development. Work will also focus on building kenaf into a solid cash crop farmers can depend upon.

"That's the real USDA mission: to get an alternative crop to American farmers," Kugler says. "And the way you do that is to develop products and markets for the raw material. Farmers will grow kenaf to supply whatever the market demands."—By **Matt Bosisio, ARS.**

Marvin O. Bagby is in the USDA-ARS Oil Chemical Research Unit, Northern Regional Research Center, 1815 North University St., Peoria, IL 61604 (309) 685-4011. ♦

Kenaf Project Wins Award

The ARS-developed process that turns kenaf fiber into newsprint was selected last month as one of the 100 most significant new technologies of 1988 by Chicago-based R&D magazine.

The award, given annually by the magazine, recognizes the chemi-thermo-mechanical pulping technique used to make the fast-growing crop into a supplemental source of quality newsprint.

Presented to the Fibrous Products Research Team at the Northern Regional Research Center in Peoria, Illinois, the R&D 100 Award was made at a black-tie dinner September 22 at the Chicago Museum of Science and Industry. Robert W. Long, USDA's deputy assistant secretary for Science and Education, accepted the award on behalf of the agency.

Members of the research team included in the award were Marvin O. Bagby, who served as research leader of the project; chemists R. Leo Cunningham and Gerald F. Touzinsky; and lab technicians Doris M. Palmer, Dale W. Ehmke, and Lynne C. Copes.

The kenaf project was chosen from among hundreds of nominations, according to Tina Lentz, R&D 100 coordinator. Each project was submitted to an outside panel of experts in the field represented by the technology nominated. The panel's comments were then reviewed by the magazine before the winners were chosen.

A display panel detailing aspects of the technology and the crop will be exhibited at the museum for 1 month.—**M.B.**

Homegrown Lubr

A small bushy lesquerella plant growing wild in Arizona, New Mexico, Oklahoma, and Texas may reduce the need to import nearly $40 million of castor oil yearly from sometimes shaky foreign sources.

Lesquerella thrives on poor soils that receive only scant rainfall—often as little as 10 inches a year. A member of the mustard family, its seeds contain fatty acids needed in lubricants, plastics, protective coatings, surfactants, and pharmaceuticals. Lesquerella grows 14 to 16 inches tall with bright yellow blossoms at the ends of its multibranched stems.

Agricultural Research Service plant geneticist Anson E. Thompson has assembled 23 of the 70 known species of lesquerella for testing at the U.S. Water Conservation Laboratory in Phoenix, Arizona. He grows plants in cooperation with the University of Arizona's Maricopa Agricultural Center.

While much more research must be carried out before a commercial variety can be released, Thompson is encouraged because he has found some species that have the potential to produce more than 2,000 pounds of seed per acre. The seeds are very small and light—about 45,000 to 50,000 per ounce. Some species have seed oil containing up to 75 percent valuable fatty acids, and some have seed pods that would make possible harvesting with a grain combine.

Thompson says that these species can evidently be improved through selection and breeding to combine the various desirable traits.

Another plus lesquerella might have is that the meal remaining after oil is pressed out may make a good protein supplement for cattle feed. Lesquerella would have an advantage over some meals because it contains good quantities of the amino acid lysine.

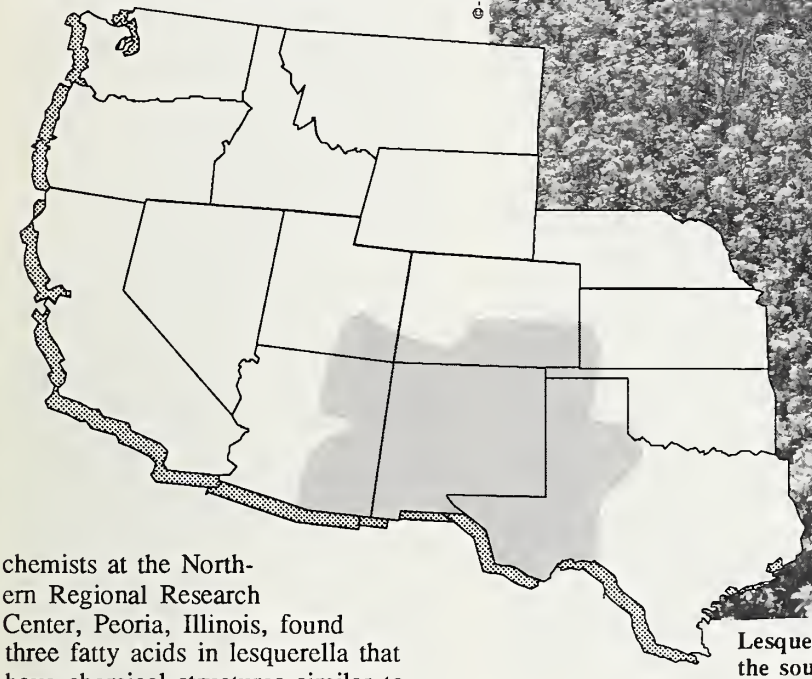
Thompson says, "We have only just begun collecting actual production data for lesquerella. In the 1987-88 growing season, after only one cycle of selection for the best producers from wild species, we obtained about 1,260

ınts and Plastics

pounds of seed per acre while using about 24 inches of water. That water consumption is comparable to winter wheat production and considerably less than the 40 inches of water that cotton needs here in Arizona.

"It looks like seeding, growing, and harvesting lesquerella can be done much as they're done for wheat and other small grains. We think seed yields would need to be about 2,100 pounds per acre to meet all production costs and make money. I am very optimistic that we can reach and exceed these target yields with a reasonable breeding effort, coupled with agronomic research to develop an efficient production system."

In the 1960's and 1970's, ARS chemists at the Northern Regional Research Center, Peoria, Illinois, found three fatty acids in lesquerella that have chemical structures similar to that found in castor oil.



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Lesquerella blossoms under the Arizona sun. Native to the southwestern United States and northern Mexico, it has promise as a drought-tolerant oilseed crop.

Foreign sources provide most of the castor oil used in the United States.

Research chemists Robert Kleiman and Kenneth D. Carlson are continuing lesquerella research at Peoria by analyzing oil and fatty acid content of plants that Thompson is breeding. They are also seeking new applications and uses for the oil.

Scientists at Lehigh University, Bethlehem, Pennsylvania, building on earlier work in Peoria, have found that lesquerella oil can be made into a new type of plastic that is tougher than most on the market today. Other such discoveries could create new demand for lesquerella, Thompson says.

In addition to lesquerella, Thompson is studying cuphea for value in replacing imported coconut and palm kernel oils (see *Agricultural Research,* February 1986) and guayule as a domestic source of rubber (see *Agricultural Research,* November/December 1984).—By **Dennis Senft,** ARS.

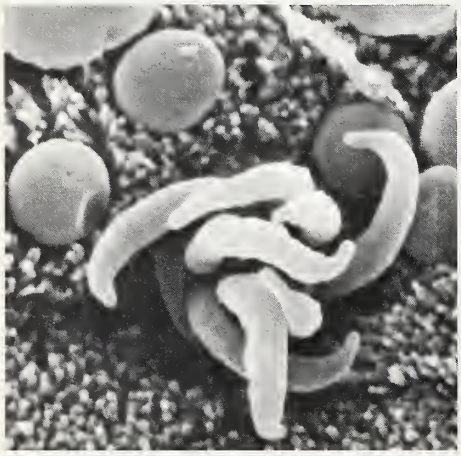
Anson E. Thompson is located at U.S. Water Conservation Laboratory, 4331 East Broadway Rd., Phoenix, AZ 85040 (602) 621-4356. Robert Kleiman and Kenneth D. Carlson are in the New Crops Research Group at the USDA-ARS Northern Regional Research Center, 1815 North University Street, Peoria, IL 61604 (309) 685-4011. ♦

The Age-Old Battle Against Parasites

In the age of AIDS, the battle against mankind's ancient enemy the parasite might seem somewhat mundane—hardly the type of work that young scientists dream of doing. But now those battle lines have crossed.

The common denominator is *Cryptosporidium,* a microscopic one-celled parasite found in domestic and wild animals and humans. Scientists have turned to one of those animals, the common cow, to produce a potent weapon against the parasite's ravages.

"*Cryptosporidium* can cause severe diarrhea in people," says Ron Fayer, a zoologist at ARS' Zoonotic Diseases Laboratory at Beltsville, Maryland. "It was discovered in 1907 by E.E. Tyzzer at Harvard Medical School. For 75 years, no one paid much attention to it, and it wasn't until 1976 that it was first found in humans."



C.A. SPEER

Eight parasites emerge from a cell living in the intestines of a sheep infected with *Cryptosporidium parvum.* (88BW1643)

According to the National Centers for Disease Control, no one knows exactly how many people are infected with the parasite because there is no formal reporting of *Cryptosporidium* infection in the United States. The parasite's path is known, however; humans become infected by swallowing fecal material that carries the parasite, sometimes in contaminated water or food.

The scientific community really took notice of *Cryptosporidium* in the early 1980s, Fayer says, "when physicians from about five states reported to the Centers for Disease Control that AIDS patients suffering from wasting, severe diarrhea were found to be infected with it. That got people's attention. Before 1970, there might have been 35 to 40 scientific papers on *Cryptosporidium*; since then, there have been almost 500."

Among scientists taking a closer look at *Cryptosporidium* is Phillip H. Klesius, a microbiologist at ARS' Animal Parasite Research Laboratory at Auburn, Alabama. Continuing work started in 1986, Klesius uses an animal *Cryptosporidium* sufferer to brew some relief for human victims of the parasite.

"We obtain a type of white blood cell called lymphocytes from an infected cow's lymph nodes. From these cells we've been able to obtain a substance that transfers immunity," Klesius says. "This transfer factor, given orally, can help cure cryptosporidiosis."

Klesius says that the transfer factor has been tested on 20 AIDS patients at New York University Medical School. Some of the patients were given weekly oral doses of the substance, taken from cattle that were not infected with *Cryptosporidium,* while others received the same substance but taken from cattle that were infected.

"Seventy-five percent of patients receiving transfer factor from the infected cattle stopped having diarrhea and also stopped shedding oocysts (eggs) of the *Cryptosporidium,*" he says. "In most cases, after the third week of oral treatment, the transfer factor initiated an immune response (to the parasite) in these patients, and there were no ill effects."

According to Klesius, AIDS does not actually destroy the body's cells that fight off this disease but instead somehow "turns off" those cells. The secret of the transfer factor, he says, "is probably an inducer molecule—it induces an immune response from the patient's own cells."

AIDS patients are not the only people who fall prey to parasites. About 40 percent of the United States' adult population have antibodies to another parasite, *Toxoplasma gondii,*

JITENDER DUBEY

White patches of dead tissue on placenta expelled from a ewe after aborting a fetus indicates the presence of toxoplasma. (88BW1645)

indicating exposure at some point to this microscopic one-celled organism.

Humans can pick up the parasite from contact with the feces of cats, the only creatures in which *Toxoplasma gondii* is known to develop through its entire life cycle. Cats get the infection by eating meat, such as mice or birds, contaminated with the parasite, or through contact with oocysts in other cats' feces. Humans can also get the infection from eating improperly cooked meat of the 20 to 30 percent of livestock estimated to be infected with *Toxoplasma gondii.*

Healthy people, other than pregnant women, probably weather the infection with little danger, says Michael D. Ruff, a microbiologist at ARS' Protozoan Diseases Laboratory at Beltsville. But it's a different matter for babies born to women who get the infection during pregnancy. Forty percent of these infants are at risk of disease symptoms, including blindness and birth defects. One 1980 report put the number of neonatal infections diagnosed annually in the United States at 3,300, with an estimated annual cost of $222 million for hospitalization, institutionalization, and special education.

This cost is more than a hundred times that of another parasite-based disease of humans, trichinosis, which was calculated in 1984 to cost $2.2 million to $3.5 million in medical expenses and lost productivity in the United States.

Nor is the parasite problem insignificant in terms of economic loss

among livestock. According to Ruff, sheep and goats that become infected with toxoplasmosis while pregnant "abort essentially 100 percent of the time—you have multimillion-dollar losses."

Despite an estimated trichinosis infection rate of only one-tenth of 1 percent in U.S. hogs slaughtered, swine producers pay the price for trichinosis in lost sales because of consumers' negative perception that "something is wrong with pork." The National Pork Producers Council estimated in 1985 that being able to assure consumers of trichina-free pork would boost domestic demand by 2 percent and pork exports by 33 percent—gains worth $449 million to pork producers.

Biblical Parasites

"There are at least two references to parasites in the Bible," Ruff says. "The 'fiery serpent wrapping around a stick' was probably a filarid worm." Its common name is "fiery serpent. The Hebrew ban on eating pork was probably tied to trichinosis. And, inscribed in ancient Egyptian heiroglyphics, there are references linking malaria to swamps."

Over the years, science has dealt fairly well with the questions of "who" and "where" regarding parasites. For example, *Trichinella spiralis,* the parasite that causes trichinosis, was formally identified in 1835. Now scientific attention is turning to the "how" and "why" of parasites, recognizing there is still much we do not know about these tiny organisms.

"The problem is we've almost always thought, for example, that parasites in the gut sucked out nutrients," says Fayer. "Instead, I think they are spilling out a lot of products into the host—even manipulating the host's immune system.

"The big questions are, how do they really cause disease at the molecular level? How do they interact with the host's immune system? Can they regulate immunity?"

Scientists across the country are seeking these and other answers. H. Ray Gamble, a zoologist at ARS' Helminthic Diseases Laboratory at Beltsville, is studying the natural resistance of St. Croix sheep to *Haemonchus contortus,* a 0.5 to 1.2-inch-long parasite in ruminants, also known as the barberpole worm because of its striped appearance. Barberpole worms rupture the stomach lining and feed on blood, causing anemia and

FRED WITTE

Zoologist H. Ray Gamble developed methods for producing antigens for swine trichinosis. (1283W1664-20)

NORITA CHANEY

What looks like an animal's head is actually the tail of a nematode, *Trichinella spiralis,* magnified 2,200 times. The larval stage of this nematode occurs in the muscles of swine and other animals and can cause trichinosis in people unless meat is well cooked. (88BW1644)

TIM McCABE

Private industry now markets a blood test kit developed by ARS scientists that can detect trichinosis in pigs with better than 90 percent accuracy. (88BW0063-7)

sometimes death. Fortunately, humans cannot become infected with barberpole worms by eating the meat of infected animals.

Gamble is also studying how the parasites develop, how their cuticle or outer covering is formed, and how it is shed at each stage of development. After an animal swallows the larvae of the parasite, an enzyme involved in the shedding of the parasite's cuticle causes the cap of the cuticle to come off, allowing the larvae to escape. Gamble is trying to identify that enzyme so he can interfere with it, perhaps causing the cap to remain on the cuticle.

Still more work is being done on barberpole worms at the Helminthic Diseases Laboratory by Michael W. Fleming, a physiologist. Scientists believe one way barberpole worms infect young lambs is by going into arrested development in a ewe's tissue during pregnancy until just before she lambs, then developing into adults and dumping their eggs on the pasture at the time when the more vulnerable lambs are most likely to be grazing.

Fleming has found he can make the female worms double their egg production to 6,000 a day by giving the infected ewe a daily dose of prolactin, one of the hormones triggered in gestation and giving birth.

He is trying to determine whether the prolactin has a direct impact on the worms themselves or somehow affects the ewe's immune system.

Microbiologist Leon W. Bone, at the Animal Parasite Laboratory in Auburn, is studying the possible use of *Bacillus thuringiensis*, a bacterium effective as a control against insects, to attack roundworm eggs and larvae on pastures. Roundworms infect cattle, living in the animal's intestines. Humans do not become infected by eating the meat of the cattle.

"We know *Bt* will kill the eggs and larvae in the lab; we've been doing this for about 3 years," says Bone. "Now we've some field experiments lined up for this summer."

Scientists at the Auburn laboratory are also developing a computer program that will consider factors such as soil temperature, soil moisture, and soil acidity to predict when parasites might thrive in the pasture—and when animals grazing there would be at greatest risk.

"The idea is to be able to forecast when a farmer should treat animals for infection," says microbiologist Dan E. Snyder.

This broad array of approaches to the control of parasites is required because there is no such thing as *the* answer, Phillip Klesius contends.

"We're looking for integrated control—on pastures, in the animals," he says. "We're not trying to eradicate parasites; that's not possible. We're trying to look at all these avenues, not as single things, but factors that we can tie together to achieve control."—By **Sandy Miller Hays,** ARS.

[If you are interested in contacting scientists mentioned in this article, write or telephone the Editor, Agricultural Research, *Building 005, Beltsville Agricultural Research Center-West, Beltsville, MD 20705 (301) 344-3280.]* ♦

Animal Parasite Research

Other parasite-related work underway by Agricultural Research Service scientists includes these projects:

• At the ARS Biosystematics Parasitology Laboratory at Beltsville, Maryland, molecular biologists Dan Zarlenga and Ray Gamble have successfully cloned in bacteria the gene for a protein produced by *Trichinella spiralis*, the parasite that causes trichinosis in swine. The natural protein is a good diagnostic tool for detecting trichinella infection. But it previously had to be obtained by growing the parasites in rats, removing the parasites, and extracting the protein from them. Zarlenga's cloned material, if proved to be as effective as the natural protein, could provide a more reliable and less expensive supply and lead to more trichina testing in swine.

• At the Helminthic Diseases Laboratory at Beltsville, Maryland, microbiologist Joseph F. Urban, Jr., and other scientists are working on ways to stimulate pigs' natural immunity to *Ascaris*—worms that can grow to more than 9-1/2 inches long and cause general malaise, slow weight gain, and intestinal blockage. Despite the availability of drugs to control *Ascaris* infection, it is still a major problem in swine. Natural immunity occurs after 12 to 14 weeks of exposure, but scientists are trying to develop a vaccine that will induce immunity more quickly in young pigs.

• Microbiologist Louis C. Gasbarre, at the same lab, has been working on stimulating immunity in calves against *Ostertagia*—stomach worms. Gasbarre has been able to induce immunity in calves aged 3 to 6 months by giving them an infection of stomach worms, then cutting off the infection with drugs at a crucial point in the worms' development. Repeating this procedure three times gives the calves 60 to 70 percent protection against the worms.

• At the Animal Disease Research Laboratory at Pullman, Washington, researchers are trying to identify the proteins that stimulate an immune response in cattle to such parasite-related diseases as babesiosis and anaplasmosis. Once the proteins are identified, the scientists try to find the genes responsible for producing those proteins, clone the genes in bacteria and viruses, and grow the bacteria and viruses to make a vaccine. Microbiologist Willard L. Goff says 5 years of research have resulted in the cloning of several proteins for possible vaccines.—**S.M.H.**

Veterinary Research Facility Underway

To ensure that the next generation of veterinarians will be well-prepared to diagnose and treat parasitic and other diseases, the U.S. Department of Agriculture's Agricultural Research Service this summer began staffing a veterinary research and training facility at the Roman L. Hruska U.S. Meat Animal Research Center, Clay Center, Nebraska. Due to be fully operational in May 1990, the $7 million facility will be funded by federal, state, and private contributions.

Research to be conducted there represents a new thrust to the study of whole-herd preventive health programs; using a production-systems approach to tackling health problems affecting animals, meat, and consumers. Veterinarians will make real-world observations about the epidemiology of animal disease--how parasitic and other diseases spread through animal populations. They'll discover the most practical ways of limiting production losses for specific diseases. Optimal nutrition to ward off susceptibility, the genetics of disease resistance, and human food safety assurance are other real-world problems that will be observed in their production settings.

"These studies represent new trends in animal health science by focusing on control and prevention of diseases in large populations of animals, rather than in individual animals," says Travis E. Littledike, at the Clay Center location.

This cooperative effort includes USDA, the University of Nebraska, and Kansas State University College. At least 100 senior veterinary medical students annually are expected to treat and diagnose animals at the facility, under supervision of the University of Nebraska veterinary faculty.—By **Linda Cooke,** ARS.

Travis E. Littledike is in the USDA-ARS Animal Health System Research Unit, Roman L. Hruska Meat Animal Research Center, P.O. Box 166, Clay Center, NE 68933 (402) 762-4177. ♦

Fruit Flies Can't Take the Hot Air

A new hot air process for zapping fruit flies may give growers in Hawaii and other tropical climates new and profitable opportunities to sell exotic tropical fruits and vegetables to new markets.

The technique--gentle on produce but tough on fruit flies--might be suitable not only for papaya but also for mango, atemoya, carambola, lychee, longan, rambutan, and other tropical specialty crops, says ARS research entomologist John W. Armstrong.

USDA's Animal and Plant Health Inspection Service has accepted the process as a federally approved quarantine treatment for papaya exported from Hawaii and is now awaiting public review of the technique.

Quarantine treatments are an extra precaution to ensure that Hawaiian-grown papaya are free of the three species of fruit flies (Mediterranean, oriental, and melon flies) that could attack it. These pests pose a continuing threat to mainland crops. But most commercially grown papaya from Hawaii is so carefully checked that it's highly unlikely a fly-damaged papaya would make it to a mainland supermarket, according to Armstrong.

Female fruit flies ruin papaya by puncturing the fruit to lay eggs just beneath the surface. The wound may also cause staining. The worms that develop from the eggs hasten rot and make the crop worthless.

Hawaiian growers sold $11 million of fresh or processed papaya to Japanese, Canadian, and mainland U.S. markets in 1987.

Here's how the new process is expected to work in packinghouses: hot air, kept at about 50 percent relative humidity (that's midway between moist and dry) is forced over the surface of papayas packed in single layers in ventilated plastic crates. The fruit is gradually heated to 117°F over a 7-hour period, then cooled with water.

Armstrong and colleagues James D. Hansen of ARS and Benjamin K.S. Hu of the inspection service adapted the process from a moist-air, or saturated-vapor, approach. But the new hot air technique is better than that and other methods in killing flies without harming the taste or texture of fruit in the shipment, Amstrong says.

That's because the saturated-vapor heat treatment with hot, moist air and the other approved treatment--a two-stage hot-water bath—kill fruit fly eggs and maggots but occasionally cause scalding or hard, permanent lumps to form in the fruit.—By **Marcia Wood, ARS.**

John W. Armstrong and James D. Hansen are with the USDA-ARS Tropical Fruit and Vegetable Research Laboratory, P.O. Box 4459, Hilo, Hawaii 96720 (808) 959-9138. ♦

Penjing Comes to Washington

PETER BLOOMER

A figurine of a musician kneels beneath a miniature Chinese elm. (88BW-1555)

At the U.S. National Arboretum—a Washington, D.C., garden place where science often meets art—31 hand-sculpted penjing trees went on public display during a ceremony on September 30.

The penjing are living poems in a Chinese cultural tradition. They are 20 to 100 years old and only 3 feet tall. They are restrained versions of forest species, alive and well, with roots in small pots.

"Penjing is the ultimate expression of a form in which art, botany, gardening, and cultural traditions mesh," says H. Marc Cathey, director of the National Arboretum. Part of the Agricultural Research Service, the Arboretum co-hosted the penjing dedication ceremony with the National Bonsai Foundation.

Penjing experts apply scientific and instinctive knowledge of plants in order to dwarf and meticulously train trees, says Cathey.

As an art form, penjing dates back 1,200 years. It has a Chinese national character, and yet there are distinctive styles that grew out of personal work of village penjing experts," says Cathey.

Penjing recaptures nature in a concentrated way, using stones and trees and ceramic figures of people, bridges, houses, and other objects as part of an integrated natural scene.

Of those penjing donated to the Arboretum, some are miniature forests with up to a dozen tree trunks under a canopy of leaves. Others are trees growing out of a rock resembling a mountain setting. Still others are single, potted specimens either upright, resembling weather-beaten elders of the forest, or gnarled and knotted clinging to a cliff edge.

The penjing trees were donated to the people of the United States by Chinese penjing experts Yee-sun Wu and Shu-ying Lui on June 25, 1986, in Hong Kong.

Since then, the trees have been under strict quarantine at the ARS Plant Introduction Station in Glenn Dale, Maryland. While in quarantine, they were repotted by the Arboretum's National Bonsai Curator, Robert Drechsler, assistant Dan Chipis, and volunteers Ruth Lamanna and Janet Lanman.

During the process, scientists with ARS and USDA's Animal Plant Health Inspection Service thoroughly inspected the trees and associated rocks, soil, and pots for possible foreign pests or diseases.

Cathey says the gifts are in keeping with the Arboretum's tradition of accepting private contributions for the purpose of maintaining its 94 gardens and rare plant collections on the 444-acre grounds.

"Without our collections and gardens, the unique research and extensive education programs at the National Arboretum would not be as vital," Cathey said at the dedication ceremony.

The occasion marked the beginning of a second phase of a 6-acre National Bonsai and Penjing Museum at the Arboretum, which has been partially financed by private donations raised by the National Bonsai Foundation. The first phase of the museum, the Japanese bonsai pavilion, was dedicated July 9, 1976. It features 53 rare bonsai plants presented by the Japanese people through the Nippon Bonsai Association.

The third and final stage will feature a North American pavilion for display of American dwarfed trees. Ground

PETER BLOOMER

A dwarf pine, painstakingly trained to appear sculptured by wind.

breaking ceremonies will be on November 18, 1988 for this pavilion.

Until construction is completed on the Chinese penjing pavilion, the penjing will be displayed in the temporary area where the dedication was held.

Cathey says the penjing gifts will join the bonsai plants on permanent public display at the Museum in order to give wider exposure to such botanical art. "Regardless of the artist's view or inspiration, these works offer their viewer a glimpse of a landscape in miniature that can be brought to a room, covered walkway, or enclosed garden. Under this intensive scrutiny, every aspect of the plant, its growing media, and container can be appraised, appreciated, and remembered."—By **Steve Berberich,** ARS.

H. Marc Cathey and Robert F. Drechsler are at the U.S. National Arboretum, 3501 New York Ave. NE., Washington, DC 20002 (202) 475-4818. ♦

TIM McCABE

National Arboretum Director Henry M. Cathey (right) and horticulturist Sylvester G. March inspect newly arrived penjing trees at the ARS Plant Introduction Center, Glenn Dale, Maryland. (0786X850-16)

PATENTS

Heat, Alkali, Convert Crops to Chemicals

Clothes, detergents, and dozens of other everyday products are made using two versatile chemicals—glycolic acid and oxalic acid.

Now these compounds can be made from cellulose or starch from the farm, instead of from fossil fuels, using a new process. And although the method might not be economical right now, that may change if the price of oil goes up.

In brief, cornstarch, corn cobs, finely ground wheat straw or rice straw, or similar starch or cellulose source is added to sodium hydroxide (an alkali) that's been mixed with water. The mixture is heated to 464°F in a high-pressure reactor (something like a pressure cooker) for 10 to 40 minutes.

The inky-looking liquid that results has 40 to 45 percent glycolic acid, and 15 to 25 percent oxalic acid—based on the starting weight of the starch or cellulose. These yields far exceed those from similar methods relying on alkali and heat to produce the acids.

While this research didn't address the final step—how to extract the useful chemicals from the slurry—it's expected that a combination of filtration, solvent extraction, and distillation will do the job.

Of the many possible new uses for the process in the future, ARS researchers are especially enthusiastic about converting farm-derived glycolic acid into biodegradable plastic products or into auto antifreeze (ethylene glycol).

For technical information contact John M. Krochta, USDA-ARS Process Chemistry and Engineering, Western Regional Research Center, Albany, CA 94710 (415) 559-5860. *Patent Application Serial No. 07/155,442, "Production of High Yields of Glycolic and Oxalic Acids From Polysaccharide-Containing Materials."*—By **Marcia Wood,** ARS.

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